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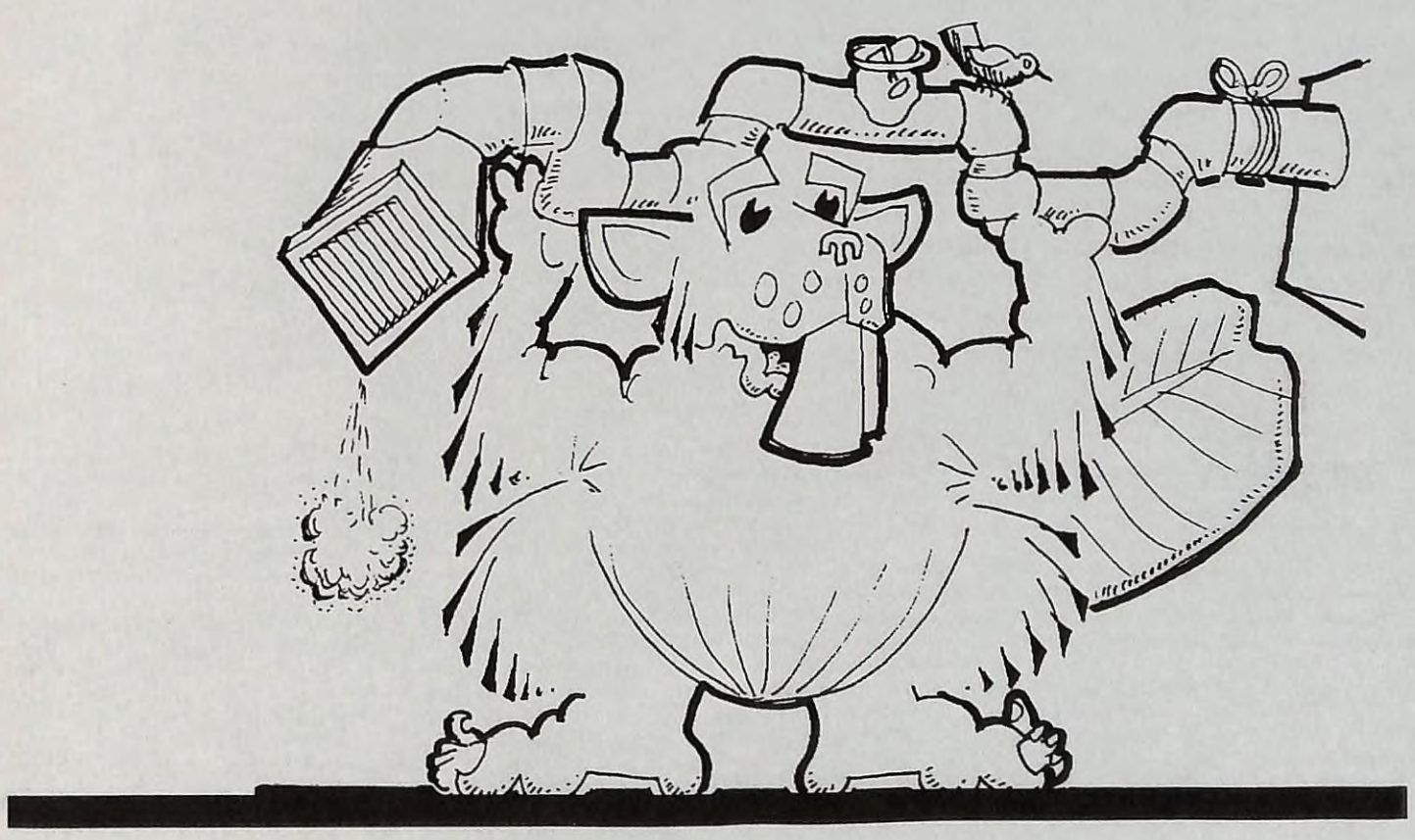
Effective HRV Installations



From the Editor

One of the delightful aspects of my work as a consultant is that I get to visit different job sites, so I get to see a lot of different projects in progress. Many tend to be high end homes which usually do not have the tight budget restraints of a modest starter home. Their builders pride themselves on the craftsmanship and quality of their work. When they are finished many of these houses are spectacular, not just because of their location and landscaping, but also because of their unique design and finishes. Many could or do grace the fashion pages of the glossy home magazines we and our customers read.

I get called to the job site when the rough framing and services are still underway, when the construction is at it's most frenetic and the innards are exposed. It is when the construction below the skin is visible. That is the time one can really judge the construction quality.

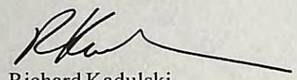
I am amazed at what I see so often. Because I am mostly seeing high end houses, I would expect to see proper detailing put into practice. In fact what I find too often is construction quality that I could expect to see on a job site of those we sometimes refer to as the bottom feeders. The type of work done by less knowledgeable players who don't know enough about the industry but who nevertheless try to maximize their profit regardless the consequences. There is plenty of poor detailing and shoddy workmanship. In some cases it is a matter of the builder or his crew genuinely not knowing any better. In other cases, it is a matter of sloppy construction practices. In all cases it is a lack of attention to quality control.

If we profess to be professionals we really must recognize that it is important to pay attention to our work and not become complacent. We must do quality assurance to make sure the work is done properly. Just because we did a detail one way on the last project and it seemed to work we cannot assume that it is okay to repeat it forever.

Unlike other industries, every house, every building we build is a prototype. The designs are different - even in tract housing there is customisation of every unit. They are built on different properties, under different weather conditions, probably using some different materials, and with different trades. Only the manufactured housing sector, producing housing units indoors under a roof in a climate controlled environment, can take an industrial approach to building although even they rely on a good degree of site work before the home is turned over to the owner.

I know there often are challenges - especially during boom market conditions. In the Vancouver and Victoria area, presently experiencing a hot market, it is difficult for many contractors to get trades in a timely fashion. Since there is so much construction activity, many contractors have to take what or who they can get and suffer. But we must be vigilant not to slide into a panic mode and let standards falter. Maybe we need to recognize that doing it right and doing proper quality control along the way might take a bit more time.

Attention to quality control not only improves the quality of housing product, it can reduce callbacks, increase the home's performance, increase durability, and help improve the industry's image.



Richard Kadulski,
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HRV Installations

Installing HRVs Correctly for Effective Ventilation

Richard Kadulski
with thanks to Tex McLeod, Gordon Cooke, Gary Proskiw, David Hill, Conrad Baumgartner

We have known for many years that ventilation is important to a healthy indoor environment. Because we spend more time indoors today than in the past, a ventilation system must operate effectively.

Traditional air change solutions, such as the opening of windows and bathroom fans, while helping air leave the house, do not provide good indoor air quality on a continuing basis in an energy efficient manner. What does work is a properly designed and installed whole house ventilation system that exhausts the right amount of stale air and introduces an equal amount of fresh air. This is the best known way to manage indoor humidity and manage air change in the home.

The R-2000 program has invested considerable effort into the research and development of mechanical ventilation systems for homes. NRCan was instrumental in seeing the development of CSA F326, the Residential Mechanical Ventilation Standard, which is referenced by the National Building Code. F326 sets out performance criteria for ventilation systems.

Training manuals and courses have been available for more than 20 years, and HRAI offers training for the design and installation of residential mechanical ventilation systems. All ventilation systems for R-2000 homes must be done by installers who've passed the HRAI course. But as with other human endeavours, things can go wrong. Even the best qualified trades and designers can screw up. That is why the R-2000 Standard requires an inspection of the installed ventilation systems before certification of a house is completed.

Generally, installation quality is much better than it was 10 years ago, even by people who aren't adequately trained. Having been on many job sites, I've observed all manner of problems with HRV installations. I also asked professionals across the country for their observations.

Sometimes the problems arise because the mechanical contractor is trying to shoehorn equipment and ducts into a space that is inadequate. This may be because neither the home designer nor the homeowner has given any consideration to the space needed for equipment. Builders must remember that the space must not only be big enough to install equipment, but it must also be accessible for ongoing service and maintenance.

Many of the problems are quite silly, but since they happen often enough, I hope that a presentation of problems seen on job sites will help improve HRV system installations. The examples and problems showcased here are not presented in order of significance or frequency of occurrence, since this was not a formal survey. However, I do want to put a spotlight on the importance of careful design and review of installed systems.

Balanced Airflows

Improper balance of the HRV system is by far the most common problem seen in the field. A system operating at excessive negative pressures can introduce soil gasses or combustion gasses into the house. If the system pressurizes the house, interior moisture can be driven into the building envelope in cold weather. It can also lead to frozen door locks making access to the house difficult.

Testing for Correct Airflow Direction

The HRV often is not balanced or tested to ensure it is operating properly. Supply and exhaust lines are mixed up, so what is meant to be an exhaust grille in practise may be supplying fresh air.

There is a simple test to check for the direction of airflow. With the system running, place a plastic garbage bag against the grille. If the flow is supposed to supply fresh air, the bag will inflate. If the grille is meant to be an exhaust grille, the bag will deflate.

This test will also be a quick check to ensure that adjustable grilles have been opened!

Controls That Don't Work

Sometimes, the controls don't get connected because the control installation was subcontracted. At other times, the connection may be left for later and, in the commotion on the job site, gets overlooked. Unless a commissioning check is done, no one will notice that the controls are duds.

Homeowner Training

Homeowners often have no clue how the HRV works, or that it has to be serviced at least once a year. This is a common problem. Operating instructions have to be left on the unit in a sleeve, and homeowners must be briefed, sometimes more than once, to ensure they know how the system works.

Properly installed and operating HRVs will be silent, (out of sight and out of mind), but if homeowners know that they have a ventilation system, they will appreciate the clean air in the home. The telltale sign that the HRV needs servicing is a deterioration of the air quality as the filters and inlet screen get plugged up, reducing airflows.

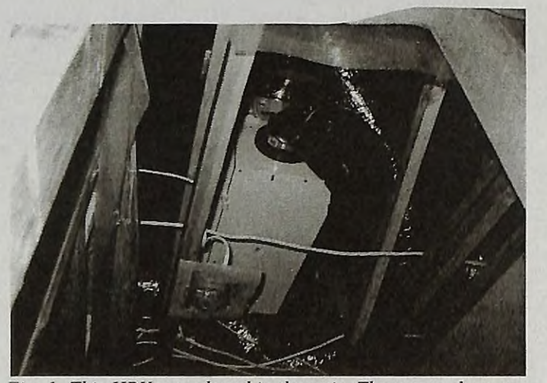

Fig. 1 This HRV was placed in the attic. The access door on the unit is on the left side of the unit and is hinged on the bottom of the unit. The face of the door is perhaps six inches away from the attic truss. How is the door supposed to be opened? In addition, the attic access is at least ten feet away from the HRV.

HRV Accessibility

The HRV should be located in an accessible location. I have seen HRVs located in poorly accessible attics or in shallow crawl spaces, far away from the access hatch.

Moisture on Cold Side Ducts

If the vapour barrier is not sealed properly, there can be condensation against the inner liner resulting in a water build-up in the duct.

Ducts on the cold side of the HRV bring cold outside exterior air into the house. Ducts from the exterior to the HRV must be carefully air-sealed, insulated and the vapour barrier-sealed. The insulation must continue directly to the HRV. Too often the insulation stops short of the HRV, leaving sections of uninsulated cold ducts in the heated space.

Too Many Exhaust Inlets on One HRV

The system must be properly designed. When there are 5 or 6 exhaust grilles on a 140 cfm system, the amount of airflow per exhaust grille gets very low and high usage bathrooms especially do not get enough ventilation unless the system has a way of zoning exhaust airflows. For example, the laundry room may not need an exhaust grille, especially since the dryer on its own is a 150 cfm exhaust fan and will draw air out of the room.

If there is a reason for having numerous exhaust grilles, the system has to be designed accordingly.

Too Much Flex Duct Is Used

A flex duct has more resistance to airflow than sheet metal, so there is less airflow than in a sheet metal duct of the same size. Where flex duct is used, it should be stretched to minimize excessive bends, and properly sized for the required airflow. Where hangers are used to support the duct, care is needed to ensure the duct is not crimped.

Flex duct length should be kept as short as possible. One installation noted had about 70 feet of flex duct (uninsulated) on one side and about 75' of flex duct (uninsulated) on the other which would mean very little if any airflow at the end of the duct.

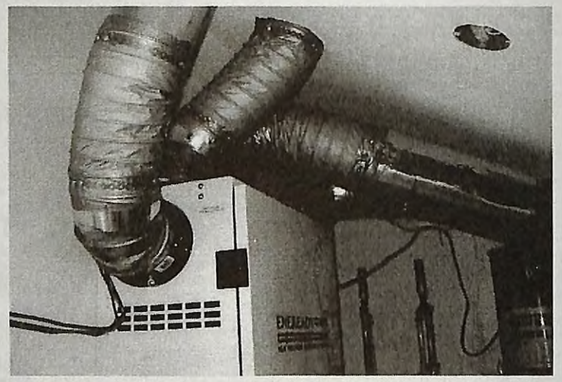

Fig 2 This HRV is located inside the heated envelope of the house. Two of these ducts have cold air in them, but none are insulated.

Ducts Outside the Heated Envelope

All ducts should be kept inside the heated envelope of the house. Sometimes the architectural design makes it difficult to keep the ducts inside the house. Placing ducts outside the air barrier, for example in the attic, requires extra attention to proper levels of insulation and the sealing of the ducts and the vapour barrier around the ducts.

When ducts are placed in the attic, penetrations of the air barrier are introduced at each location where a duct re-enters the house. Unless an air test is done to verify the airtightness of the home, there could be considerable air leakage out of the house into the attic, around the grilles, taking with it not just heat but also moisture from the interior.

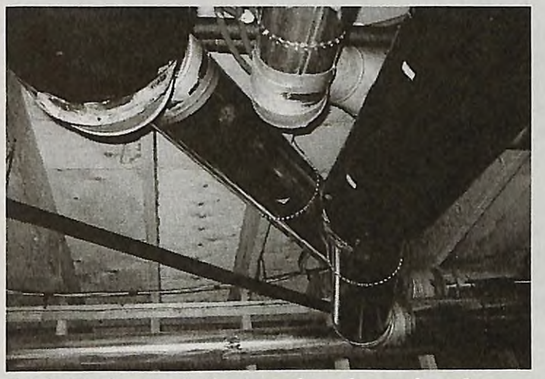

Fig 3 The ducts in the foreground are the supply and exhaust ducts to the HRV on the cold side. You can see the insulation, but it stops well short of the HRV, as can be seen by the uninsulated sheet metal ducts, so the last few feet are cold. There is no obvious reason why the installer would have stopped the insulation short of the HRV.

Inadequate Supply or Exhaust Airflow

Often insufficient allowance is made for the resistance of inlets and outlets. Their nominal size maybe significantly different then their effective size, restricting airflow. Some screened hoods that are being used are undersized for the intended airflow.

The ductwork may be too restrictive, or poor fittings are used. Rather than 'Tee' fittings, 'Y' branches are better, but they must be installed correctly for the direction of the airflow. The system design must take into account the total resistance of all the fittings.

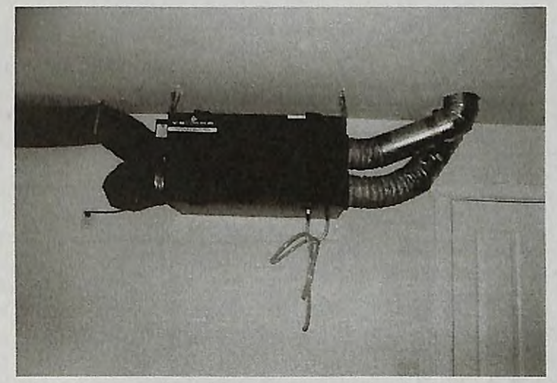

Fig 4 Ducts on the cold side of the unit (on the left) are insulated. The warm air side ducts, on the right hand side, are not insulated, even though this unit is located in an attached garage (which is always considered to be outside the heated envelope of the house.)
Hanging the HRV in the garage is <u>never</u> a good idea, since garage gasses can be picked up and introduced into the house through leaks in the ducts and HRV (which is never perfectly airtight) and the joint where the duct penetrates the home's air barrier.

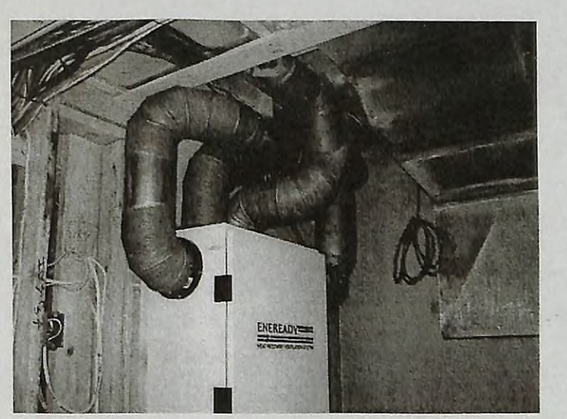

Fig 5. Complex ductwork in a tight space, well put together and carefully sealed, but ducts on the cold side, bringing outside air into the house and exhausting stale air are not insulated.

For information on the R-2000 Program, contact your local program office, or call 1-800-387-2000 www.R-2000.ca

Manufacturer literature must be reviewed for airflows at the pressure the system is operating at for each fitting and grille. Those grilles that are adjustable must be properly set up. And the installed system must be verified that proper airflows can be provided.

Leaky Ducts

HRV systems have smaller fans, operate at a lower duct pressure and with smaller volumes of airflow than forced warm air heating systems. As a result, they do not support the same air leakage levels that can be tolerated in heating system ductwork.

Unless ducts are screwed together, sealed at all joints and seams and at all elbow gores, 50% or more of the ventilation air could be lost to leakage rather than being directed to where the design intended. This problem can show up in the ensuite bathroom on the third floor at the back of the house with the whirlpool tub and the skylights, which gets no exhaust, or in the back bedrooms in a non forced air heated house, which remain stuffy all the time.

Fresh Air Inlets Improperly Located.

Fresh air intake hoods must be kept a minimum 6 feet away from the HRV exhaust or any other exhaust from the house, including gas metres, garbage cans and parking spaces, otherwise contaminants can be pulled back into the house. A fresh air inlet on the roof, especially on an asphalt shingle roof, is not a good idea.

As well, the outside fresh air intake must be at least 18" above finished ground. In snow belt areas intakes should be placed high enough so that the snow does not obstruct the inlet. One suggestion made is to place the intakes at the soffit level. The ceiling of the front porch is a good place, as long as that is not where the smokers will sit and feed their habit.

Fresh air inlets must be accessible for cleaning. The insect screens do get plugged up with leaves, spider webs and other debris, blocking the screen to cut off all airflow, so they need to be cleaned frequently. Depending on the climate and amount of biological activity, the inlet screen may have to be cleaned 3 or 4 times per year.

Fig 6 The side by side hoods on the roof of this house are the inlet and exhaust for the HRV. Fortunately for this builder, this error was spotted at a time when changes could still be made relatively easily.

Too Much Noise

Today's HRVs are well designed machines with quiet motors, so they should never be heard. Improper installation and incorrect sound isolation details can lead to noise. The HRV must be suspended by the flexible straps supplied by the manufacturer, and the ducts must have a section of flexible sound attenuating ductwork.

No Distribution of Fresh Air

The fresh air brought into the house must be distributed throughout it. It can be done by way of a dedicated supply duct system or as part of the forced warm air heating system ducts, in which case the furnace fan should be running continuously at a low speed. The HRV should never just dump the air into the basement.

Defrost: Use of Proper Equipment.

HRV equipment is available with and without defrost options. In cold climates the HRV must have a defrost capacity or the unit will freeze up, blocking all airflow. In mild climates, like coastal BC, there is so little frost, defrost is not an issue, so equipment commonly used does not have a defrost option.

The equipment selected must be appropriate for the climate where it is to be used. ☼

Vapour Barrier Properties

The design of exterior walls to manage moisture in the building envelope has become more complex in modern buildings because we insulate the walls more and use new materials.

Bulk moisture is obvious, visible and relatively easy to understand: It is the rain, sleet or snow against the side of the building. Large quantities of moisture are deposited during relatively short time periods.

Vapour diffusion moves small quantities of moisture (measured in nanograms, or millionths of a gram per square metre). The driving force may be small but it is long term and constant as long as there is a vapour pressure differential across the wall. This means a temperature difference between inside and outside.

Without a proper vapour diffusion strategy, the short and long-term performance or durability of a wall can be seriously affected. Moisture can enter a wall assembly by direct entry through holes and gaps such as poorly executed flashing details, cracks and gaps in the cladding and penetrations of the assembly. It can also enter by diffusion of water vapour through the materials themselves.

The air barrier and vapour barrier are two distinct elements in the building envelope and the Building Code identifies them as separate issues. However, the role of the vapour barrier is often misunderstood. There is considerable controversy and confusion about whether or not it is even needed because polyethylene is normally used for both the vapour barrier and the air barrier. The vapour permeance characteristics of the vapour barrier are important to how a wood-frame wall performs.

In the absence of any air leakage, moisture in the form of water vapour diffuses through the wall assembly due to a water vapour pressure and/or temperature gradient across the wall. The direction of water vapour movement depends on the exterior climate and indoor environment.

The purpose of the vapour barrier is to control the moisture movement by diffusion from the warmer part of a wall assembly to the colder part of the wall. That is why it is required by the Building Code, which states the vapour barrier must not exceed 15 ng/(Pa.s.m^2) or 60 ng/(Pa.s.m^2) depending on the permeance of other materials in the assembly.

Although there is no evidence of problems as a result of compliance with the NBC prescriptive requirements, questions remain regarding the specific limits prescribed especially in the mild and wet Vancouver climate. Suggestions have been made that it might not be necessary to install a vapour barrier in Vancouver. However, these are based on studies done with simplified constant interior boundary conditions, neglecting the effect of driving rain, solar radiation and wind velocity on the water vapour movement through the wall assembly.

A recent study at the National Research Council looked at vapour barrier options in a stucco clad wall in the Vancouver climate and how they would affect the performance of the wall. Although it was a computer simulation analysis, the software used is a new research tool developed by the National Research Council. A number of factors are considered, including heat, air and moisture movement through a wall over a two-year period. It also takes into account normal variations in the building over time, such as air change and the moisture released by occupants.

The study found that removing the vapour barrier entirely from the wall system can result in the accumulation of moisture in the interior gypsum board which could lead to the board's premature deterioration. Although a vapour barrier is needed, the issue is what the properties of the vapour barrier need to be. A vapour barrier with too high or too low a vapour resistance would not provide an optimum moisture management strategy in a stucco wall such as the one looked at in this study.

The simulation results indicate that an acceptable range of vapour permeance for the vapour barrier in a wall assembly could be much wider than in prevailing practices. For the Vancouver climate, the study showed that a vapour barrier with a vapour permeance value between 60 and 1000 ng/Pa.s.m^2 would produce an optimum moisture management.

A very high or low permeance of the vapour barrier does not produce the optimum moisture management strategy. The lowest vapour permeance produced the most severe moisture response. A more permeable vapour barrier can reduce the intensity of the moisture response. In

Vapour Barrier and Moisture Response of Wood-Frame Stucco Wall: Results from Hygrothermal Simulation *a paper presented at the CIB World Building Congress 2004, Toronto, by Dr. Phalguni Mukhopadhyaya, Dr. Kumar Kumaran, and David van Reenen, all from the Institute for Research in Construction, National Research Council of Canada.*

other words 6-mil polyethylene, with a permeance of 3-5 ng/Pa.s.m² is too good a moisture barrier and could be a problem. It may be possible to remove the polyethylene as long as the required vapour diffusion resistance is provided by other materials. However, all other aspects of proper design and construction must be followed, including achieving an airtight building envelope.

This study looked at a wall section in a typical residential environment the mild wet maritime climate of Vancouver. Results might vary somewhat in other climates or in more extreme environments, such as an indoor pool or spa. ☼

Managing Moisture and Wood

Managing Moisture and Wood, by the Canadian Wood Council. Building Performance Series No. 6

Even though wood can withstand much abuse, it has to be handled and stored properly. Although there are standards in place, poor handling of wood has been a considerable problem in some regions. To deal with builder concerns, the Canadian Wood Council has prepared a publication in its Building Performance series.

Proper moisture management in wood products is essential to control swelling and shrinkage and prevent problems associated with mould or decay. Wood changes dimensions with changes in moisture content throughout its life in relation to seasonal changes in relative humidity and temperature. It swells when it absorbs moisture during wet or humid conditions and releases moisture during dry periods. Lumber shrinkage is much larger across the grain, and is negligible parallel to the grain.

Dry lumber is structurally stronger with much less chance of fungal growth such as mould, stain or decay, reducing swelling and shrinkage that could lead to warping or other problems. The "S-Dry" label indicates that the lumber was surfaced at a moisture content of 19% or less. Panel products such as plywood or OSB typically have a moisture content of 4 - 8% when manufactured.

Wood is a good moisture sink and will help balance the humidity fluctuations in a building.

The wood moisture content (MC) is a ratio of the weight of the oven-dry wood. If a board has a MC of 25%, one fifth of its weight is water. The wood moisture content has to be high (30% or more) for an extended period in order for wood decay to set in. Most fungi grow fastest in the 60°-80°F (15-25°C) range; they grow very slowly or not at all around freezing.

Wood that is in contact with water over a long period of time can become discoloured for various reasons and may grow fungi, including stains, moulds and decay. If it stays wet, it can take on a darker appearance due to the water which will disappear when the wood dries again. If the wood stays wet for too long, it may become permanently discoloured.

Only decay will affect the structural performance of wood; other forms of discolouration will not weaken it. Decay fungi are different from moulds and staining fungi. Moulds and stains feed off the free water and the sugars stored inside the wood but don't affect its strength. On the other hand, decay fungi will gradually consume the wood if it remains wet for too long.

Although conditions for mould and stain growth are also favourable to decay, the presence of mould or stain does not indicate that decay is present.

Most wood construction materials, even those intended for interior use, are often left outside for a length of time where they can absorb moisture from rain, snow or the ground. Outdoor storage on the building site should be minimized to limit potential damage caused by exposure to moisture.

Handling Green Lumber

- A water-based formulation containing a low level of an anti-microbial chemical is sometimes applied to lumber that is sold green to prevent the growth of staining fungi or moulds on the lumber before it is used.
- The chemicals used for treatment are mild, such as detergent type chemicals or fungicides used on agricultural food products. Their protection time on green lumber is therefore limited.
- Prior to using them, determine that the products are safe for use under the conditions given on the pesticide label.

Points to remember when handling wood products

- Ensure that the storage area is well-drained and clear of obstacles, debris, and vegetation. (Vegetation can harbour insects, prevent good ventilation and keep air moist)
- Examine the wrapper upon delivery as tarps easily develop holes on corners or other points of stress.
- Don't remove specialty wrapping until the lumber is ready to be used.
- Fix or replace any damaged wrappers with a good quality tarp. If the wrapping is damaged, re-cover using a waterproof tarp. Don't let water leak through torn wrappers.
- Tarps should not be tucked under the pile or wrapped tightly.
- Make sure the tarp covering extends beyond the bundles.
- Polyethylene tarps are efficient at protecting wood from soil moisture, but used as a wrapping material they may keep moisture trapped inside the pile.
- Have the material delivered as close to the installation date as possible; materials left exposed risk water absorption and deterioration, as well as theft.
- Don't dump lumber bundles directly on the ground.
- Store materials off the ground. If the soil is wet or poorly drained, place a polyethylene tarp or a temporary gravel pad on the ground below the supports for the materials.
- Don't store wood products in basements.
- Protect the materials after they have been installed by closing the structure quickly.
- Provide enough time and ventilation for the materials inside the wall cavities to dry to an acceptable level before installing the vapour barrier.
- Keep packages of lumber, trusses, I-joists and panels 6 to 8 inches off the ground (dry wood in contact with the ground will quickly take up water).
- Store bundles as level as possible.
- Horizontal wood components need more time to dry.

If Wood is Re-Wetted:

- Wet wood dries from the outside in. When wetted, wood will dry quickly on the surface and limit mould growth.
- With tidy piles of panel products, the top panel can retain the moisture but most of the water runs off and does not readily penetrate into the pile. Piled lumber can be more vulnerable as rainwater or snowmelt percolates in between the lumber pieces and may wet several layers. Such water is held between the boards in a film by capillary suction that wets the surfaces. Wood in this situation could remain wet long enough to develop surface mould or wood-staining fungi.

Wetting After Installation

- Lumber will dry out naturally so long as it is well ventilated and the humidity level of the air is not high.
- In cold weather, space heaters may need to be used to help with drying.
- Avoid closing in walls that have wet building materials.
- Often, by the time green lumber has been shipped from the sawmill, it is partially air dried. Manufacturers rarely wrap packages of green lumber. Upon arrival at the building site, green lumber is best stored indoors.

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Sustainable Housing

High Tech? Low Tech? Which Is Better?

by Shawna Henderson

Recently, on one of the e-mail discussion groups that I subscribe to, there was a hot and heavy thread that centred on the 'right' approach to sustainable building. One faction argued for small 'low-tech' houses with all-local materials with minimal energy input/outputs, while dismissing all 'high-tech' gadgetry, and the discussion started to degrade into an "I'm right, you're wrong" set of responses.

This high tech/low tech argument is a classic red herring, one that can easily put like-minded designers and builders at loggerheads, endangering collaboration and the synergies that help move the home-building industry forward. In fact, there are few areas where the two approaches can be readily disentangled.

My favourite example of twinning low and high tech approaches is glazing. We can specify windows with varying layers of glass, low-e coatings, gas-fills, insulating spacers and frames to minimize/maximize heat loss or gain by orientation. These are all innovations based on 'high-tech' thinking that results in huge performance improvements for humble, long-proven passive solar heating/cooling measures. Should we return to locally-built single or double pane windows fitted with insulating shutters that homeowners must lug around on a daily basis? Or should we take full advantage of new window technology and install windows that are net annual energy producers?

While I argue for taking the best of both worlds and developing elegant solutions for low-impact housing, I have strong feelings about the misuse of the labels 'green', 'sustainability', 'renewable' and 'zero net energy'. These terms are being used in reference to monster houses that gobble up resources for the sake of a vision of the perfect 'home as a castle'.

Incentive and demonstration programs that showcase huge houses with all the latest gadgetry don't bring the possibilities closer to the majority of home buyers, for whom the 7,500 sq.ft., two- or three-bedroom home is a joke. Indeed, these programs do little or nothing to aid the spread of new technologies, new approaches to construction and design, or implementation of renewable energies, simply due to the size and expense of the systems installed.

There are brilliant examples of careful sustainable design that use minimal resources and are powered/heated by tiny renewable energy systems. Solar thermal, building integrated PV and other products such as greywater heat recovery systems are high on my list of useful technologies, so are high-performance glazing, straw bales and passive solar design.

If we are to make a dint in the energy and resources squandered in the 100,000s of new housing starts, for both homeowners and for the building industry in general, commercial add-ons are one place to start. Only a small percentage of the home buyer population is willing to get its hands right into the project and reinvent the wheel with low-tech, one-off, on-site solutions. Unfortunately, they will not make any major change in the way that larger society uses – or perceives – innovative or sustainable technologies. They may be in the vanguard, but adamant attitudes about what is 'right' will only maintain the marginal status of renewables, passive solar and other excellent sustainable technologies.

These are my observations after 15 years of working in the field of energy efficiency, passive solar and other aspects of sustainable housing. Over the years, I have watched Canada's vaunted R-2000 program deteriorate from an international leader in energy-efficient housing to a watered-down version marketed as a 'lifestyle' home, where saving 50% on your heating costs means you can afford more square footage, versus reducing energy use. Change on a broad scale will happen when stronger national legislation on energy use in general forces the building industry to market zero-low energy houses.

Abri Sustainable Design is completing a study for CMHC that looks at low impact housing in cold climates. Most of our examples are from Europe. The EU has a real leg up on us – about five years – in terms of developing affordable, sustainable housing on a broad scale. This is the result of strong regional and national incentives, energy use standards and well-coordinated research and development programs. To view over 180 international 'low-impact' housing projects. Visit *www.abridesign.com/lowimpact*. A publication featuring 24 in-depth case studies from this on-line survey should be available by early 2005.☼

Shawna Henderson is principal of Abri Sustainable Design & Consulting. Based in Nova Scotia since 1997, Abri offers expertise in sustainable housing design, research and development.

Solar Electricity

Net Metering Comes to BC

The sun delivers solar energy to earth free of charge. Photovoltaics is the technology that converts the sunlight directly into electricity. It is the most environmentally friendly means of generating electricity. The first practical photovoltaic cell was developed in the mid 1950s to power satellites. Since that time the applications and the costs have come down to earth. The first terrestrial applications were for communication stations and remote home sites beyond utility lines.

World wide there has been tremendous interest in the use of small photovoltaic systems to provide electrical power. Many are now looking at this technology to displace some or all of their conventionally generated electricity.

However, solar electricity is only produced during daylight hours, when it may not always be needed. Stand-alone solar electric systems are expensive because they need to accommodate battery storage to provide power for nighttime use. Another other option is to feed the excess to the power grid. This approach recognizes that solar electricity provides a portion of the total power supply, with other sources making up the balance.

Most electric utilities are still reluctant to connect small residential photovoltaic power supplies to their distribution system because distributed generation from many small suppliers is a significant change in the utility business, not only on the technical side, but also on the financial management side. The perception on the part of many utility mangers is that such an approach to generation is just an added cost.

In the US and many other countries electrical utilities allow the use of reversible meters. With reversible meters, the unit runs forwards and backwards depending on the direction of power flow and the net value is read at the end of each billing period. In other words, the customer is selling excess power to the utility.

Distributed generation of electricity is generally good for the electrical utilities because it reduces the excess generating capacity that is required to maintain a reliable power supply. Since power demand usually peaks in the day because of industrial and commercial users' needs and for cooling loads in summer, solar electric generation profile matches peak demand and helps shave the utility's generation during peak load conditions.

In the US, many states have legislated net metering. That has not been the case in Canada, where the large provincial crown owned utilities have tended to focus on large generating facilities. However, with the need to exploit more "green" power, and growing power demand, that is about to change.

The BC Utilities Commission has recently approved metering for BC Hydro, making this is the first Canadian utility to allow net metering. The new metering tariff is available to all BC Hydro customers with a generation capacity of 50 kW or less. The utility will purchase power for a price equal to its avoided cost for green energy which currently is equal to 5.4 cents/kWh. (Currently the BC Hydro residential rate is 6.1 cents/kWh.)

For systems up to 5 kWh capacity, BC Hydro will pay all incremental costs associated with meter installation, reading and billing. For larger systems, up to 50 kWh, there will be a cost of up to $600 for an on-site check of facilities. Interconnection must be done safely, but the rules governing interconnection will not be extensive or burdensome in administrative process.

The net metering is intended only for locations where the generation is primarily for use at the installation. Customers will only be billed for their net consumption, thus allowing participating customers to offset their own consumption billed at BC Hydro's retail rates. Net excess generation may be banked as a credit to the customer's account to be applied against future net consumption.

BC Hydro does not anticipate that net metering of small generators will produce significant qualities of energy, nor do they expect many customers to take up the challenge. ☼

Spheral Solar Power

Solar cells produce electricity through the direct conversion of sunlight into DC electricity. Traditional solar cells consist of thin fragile silicon crystal wafers that must be cut and assembled into a panel that is covered by glass and encased in an aluminum frame. This is an expensive process that also adds weight and rigidity, and significantly limits application. A significant breakthrough in solar cell manufacturing has been made by a Canadian company.

Spheral Solar Power, a division of ATS Automation Tooling Systems Inc. of Cambridge, Ontario has developed a unique solar cell manufacturing process. Spheral Solar™ cells are made from thousands of tiny silicon spheres bonded to a thin, flexible foil substrate and covered with durable, weather resistant materials. These flexible cells can be assembled into lightweight modules of varying sizes that can be applied to virtually any surface. Unlike conventional solar panels, they are flexible and virtually unbreakable.

Spheral Solar products can be manufactured from many grades of silicon, thus reducing exposure to raw material price and supply fluctuations. The manufacturing process is automated, and can produce significant quantities of product at a significantly lower cost than the traditional crystal panels.

Spheral Solar technology will make solar power available to a vast array of new applications (such as roofing tiles) more economically – so that in the near future the shingles will be available that will economically not only provide a roofing product but also provide power at the same time.

An indication of Spheral Solar's commitment is that the plant, which is about to start commercial production, represents a $100 million investment. The first product should be coming off the production line this October. Initially, they will produce a series of flexible panels for the recreational market and then expand the range of applications.

The fast adoption of solar electric applications means that it may still be a while before we see the benefits of the significant price reductions possible by innovative breakthroughs like Spheral Solar. The worldwide demand for PV is so strong that all manufacturers have production committed through to 2006. ☼

Information: Spheral Solar Power
Tel. 519-650-6513
www.sspsolar.com

Letter to the Editor

Re: Moisture Movement through Concrete Foundation (Solplan Review No. 117, July 2004)

I have been receiving Solplan Review for a few years, and I have to say that your views on residential construction have retained my interest.

I found it interesting that somebody would suggest the installation of a drain tile lower than the bottom of the concrete footing pad. My suggestion for the same problem is to deal with the issue of moisture penetration into the concrete foundation. I wonder if someone else has considered placing 6 mil polyethylene on the ground under the footing. I think that the footing unprotected from ground water will absorb water across the full face of the bottom of the footing and redistribute the moisture into the concrete wall.

I have installed polyethylene on the ground before the footing pad is poured and it works well. Poly under the footing plus the lower drain tile and wall membrane you suggest would now provide a complete barrier from below the basement floor slab to the top of the foundation wall.

I wonder if this kind of detail could damage anything? I have to admit that by placing poly under the footing it took longer to cure the concrete, but I think it should only make it stronger because it dries slower. Do you have any comments?

Thanks. Keep up the good work.

Pierre Mourant
Caraquet, NB

What you describe is an excellent way to stop ground water from being wicked into the building through the concrete. I have seen some builders in the Vancouver area doing exactly what you describe – they line the footing form with polyethylene before pouring the concrete. As well, there are fabric forming systems (such as those by Fab-Form Industries Ltd. of Surrey, BC) that use waterproof membrane materials for forming and moisture management. Other than longer cure times, and some extra care during the pour, there is nothing negative about this detail. Ed.

Technical Research Committee News

Canadian Home Builders' Association

Canadian Electrical Code Changes

The Canadian Electrical Code is a Canadian Standards Association (CSA) standard with a focus on dealing with shock and fire hazards of electrical installations. It gets updated periodically to deal with changing technology and operating conditions.

Anyone can request a change, which is then evaluated and the level of support in the community and industry is assessed. Substantial agreement among committee members, rather than a simple majority of votes, is necessary. Changes can be adopted at any time the CSA standing committee thinks it is appropriate.

The committee structure tries to balance vested interests among various stakeholders. They use a "balanced matrix" approach, so that each committee is structured to take advantage of the expertise of its members - with no single group dominating.

As a CSA document, the procedures for review of the Electrical Code are different from the extensive public consultation procedures by the Canadian Codes Centre for the National Building Code. Users affected by CSA standards do not always hear about proposed changes when they are being reviewed, hence they don't get a chance to register their comments. Committee members themselves can propose and vote on changes, rather than just reviewing proposed changes.

While most recent changes apply to larger scale construction and electrical systems infrastructure, some have potentially significant impacts on the housing industry, such as the requirement for an Arc Fault Circuit Interrupter (AFCI). Unfortunately, that passed with little input from the homebuilding industry. That is why CHBA has become more proactive, maintaining a standing watch on activities of the Electrical Code committee. Any electrical contractor members who have an interest in helping review and comment on proposed changes are invited to contact Don Johnston at the CHBA National office.

Potential changes currently under discussion in the US are to require AFCI on all circuits in a house. In today's world with the move to harmonized standards, if that is approved in the US, the pressure will be on to introduce similar changes in Canada. In Europe, an AFCI is put on the whole house circuit, rather than individual circuits.

Builder Technical Series from CMHC

CMHC has announced a new series of technical information pieces. They plan on publishing 12 issues per year. The publications will be published under the "*Builder Technical Series*" label. They will parallel the *About Your House* series, but will be targeted for a builder audience, so will have a more technical content than the consumers' series.

Sidewall Vented Gas Appliances

High efficiency gas appliances are usually vented sideways through the wall rather than through the roof. Since the main byproduct of gas consumption is water vapour, the water can condense on the wall cladding, leading to deterioration. This could especially be a concern with rain screen detailing. Could there be a build up of moisture in the cladding and in the cavity behind the cladding? Could this create any problems in cold winter conditions?

CHBA will be canvassing the warranty programs to gauge the extent of any problems. If any readers have observed any problems with the sidewall vented appliance vents, whether in a rain screen wall or not, let CHBA TRC know.

Radiant Foil Insulation

Proponents of radiant insulation have made outrageous claims about the insulating value of radiant foil insulation materials. The claims have been based on incorrect or inappropriate interpretation of test results.

To provide some definitive answers, a variety of insulating materials were tested. Preliminary results have confirmed previous findings, and what has been known to physicists for a long time. A 'bubble-pack' radiant barrier under a slab has an insulating value of RSI 0.4 (R-2.2), while 50 mm extruded polystyrene has an insulating value of RSI 2.13 (R-10).

The Technical Research Committee (TRC) is the industry's forum for the exchange of information on research and development in the housing sector.

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Energy Answers

Rob Dumont

If you were to build your house again, what measures would you change to improve its energy efficiency?

For those not familiar with the house, it is located in Saskatoon and has some of the highest insulation levels in the world. The attic has R80, the walls R60, the basement walls R60 and the basement joist floor R35, all of which are cellulose insulation. Someone once described the house as "the best insulated on this planet, or any other planet, for that matter."

A picture of the south side of the house is shown in Figure 1. The north facing front of the house is shown in Figure 2.

We take advantage of both passive and active solar to provide heat for the house. The south facing passive solar windows are 151 square feet. The single glazed active solar panels are 168 square feet in area with a heat storage tank of about 650 imperial gallons. Five kilowatts of electric baseboard heaters are used for auxiliary heat. The house is very well sealed at 0.47 airchanges/hour at 50 pascals. (The R-2000 standard is 1.5 ac/h at 50 pascals.)

In addition we have some relatively efficient appliances (vintage 1992) and mostly compact fluorescent lighting.

As the house was built in 1992, there are definitely some upgrades that could be made.

Here are some of the measures that I would include in a new project:

1. Building orientation

No basic change. I would once again opt for a lot with a south facing exposure on the back of the house. The one change I would go for would be to have adjacent lots with minimal trees. The trees on my neighbour's lot to the west obstruct some solar gains in the afternoon.

2. Building shape

Our current house has just four corners and its shape is surpassed only by a cube or a sphere in terms of having a low surface area to volume ratio. Low surface area implies low heat loss. I'd go for a similar shape.

3. Building insulation levels

I would not increase the insulation levels. Other areas offer more promise given current technology. I would also stick with wood frame construction, including the wood basement with a suspended wood floor. I haven't seen any products that can compare with wood as a building material for low embodied energy, carbon fixation, and ease of incorporation of very high insulation levels.

4. Windows

The current windows are wood framed, triple glazed units with two low e coatings, argon gas fill and a low conductivity spacer bar (swiggle strip). The operable windows are all casement units. Over the 12 years of operation the windows have performed very well. On only one unit is there a seal failure, which periodically manifests itself as some window fogging. Murphy's law also ensured that it was the most used window – i.e., the window in front of the kitchen sink that has this problem.

For improved windows on the east, west and north exposures, I would go for quadruple glazed units with low e coatings, krypton gas fill, low conductivity frames and low conductivity spacer bars. The casement design (side-hinged) would again be my choice.

Figure 1. South side of Dumont Residence

Figure 2. North side of Dumont Residence

On the south side of the house, I would use the HOT-2000 program to optimize the south window area and select the type of window. The ideal window would have 100% transmission of solar energy and 0% heat loss. We are not there yet, but the computer program could help me select the best option. Some passive solar designers in Saskatoon's climate use only double glazed windows on the south side – computer simulation of the actual house is probably the only way to tell if that is the best option. Although triple and quadruple glazed windows have superior R values than double glazed, the useful solar gains are reduced with three and four panes of glass.

I would be careful about putting too much south glazing in a wood framed residence. Ken Cooper of SAR Engineering did an excellent study for CMHC looking at the problem of overheating in southern Canadian houses from too much south glazing. He concluded that October was the month that most houses would overheat, and that to avoid overheating the south window area should never be more than about 10% of the floor area. For an Advanced House with low internal heat gains (12.9 kWh/day) and low thermal mass, the south window area should be limited to about 3.5% of the heated floor area to avoid excessive overheating. I myself don't mind some temperature swing. One thing that we did to increase the thermal mass of our house was to place all the scrap gypsum board in the wall cavities. It solved two problems – the house is a little heavier, and landfill waste was reduced.

5. Better exterior doors

We have three exterior doors, all of which are steel clad doors with polyurethane foam and wood framing. Although some manufacturers claim as high as R14 for such doors, the bitter reality is that the overall R value is about R6 because of all the thermal bridges through the wood.

I suppose that one could go to a thicker door, but an alternative would be to use exterior storm doors on each door.

6. Better appliances

Our refrigerator, a Woods all-refrigerator unit, has performed well over the years. Although it is rated at 432 kWh/year, I measured it with a kilowatt hour meter, and it was using only about 300 kWh/year. It does not have a fan-forced automatic defrost; instead, a passive "eavestrough" collects condensation off the evaporator coil and directs it to a simple pan located over the motor. The heat from the motor helps to evaporate the condensate.

Our chest freezer is definitely an energy dinosaur, using about 700 kWh/yr. A newer unit of the same size can use as little as 354 kWh/yr.

Our clothes washer is a top loader rated at about 900 kWh/yr, and definitely would be replaced by a front loader that uses as little as 196 kWh/yr.

Our dishwasher would also be upgraded. Our current unit uses about 900 kWh/year, and newer Energy Star units are rated at as low as 312 kWh/yr.

7. Air tightness

I am satisfied with the air tightness level in our current house – it's about three times as tight as the R-2000 standard, and we never have any problem with drafts or unevenly heated spaces. For instance, we can heat the entire top floor of the house with a 1 kW electric heater as long as the interior doors are left open for circulation.

8. Heat recovery ventilator

Our current house has a Van EE 2000 Plus HRV that was custom made with brushless DC motors. The unit uses about 68 watts on low speed, providing about 100 cubic feet per minute of ventilation air continuously to the house.

I have heard that there is a German HRV manufacturer that produces a heat exchanger using only about 20 watts of electricity – I would try to locate such a unit.

8. Space zoning

I would put a few more doors in the house. That way one could put insulation in the interior walls and heat only parts of the house that are used. My wife, daughter and I have a lot of space, and it is not all that well used. Both my wife and I come from large families and we thought we would have a larger family, but it was not to be. Another approach I would look at would be better space usage and a smaller home.

9. Electricity supply

At present we do not use any photovoltaic (PV) generated electricity. We do, however, have the garage oriented so that PV can be added. If you are already on the grid, PV is one of those energy investments with the smallest rate of return. As time goes by, I would think that the cost of PV will shrink and it would be more attractive. I would

plan for its eventual use by orienting a surface at about the latitude angle (52 degrees in Saskatoon) from the horizontal for any new building.

10. Active solar panels.

All columnists like to think of themselves as omniscient, and your humble scribe is probably not that much different.

I do admit, however, that I installed the solar collector outlet temperature sensor incorrectly with the consequence that the sensor was reading about 15°C too cold. I made a serious error in not commissioning the control system for the panels, and the result was less than optimum collection. Thus, commissioning would be a high priority.

Another problem I have noticed is that parts of the selective surface absorber plates on the solar collectors have become detached from the half-inch copper pipes that carry the propylene glycol mixture. Again, this is my fault, as I built the solar panels myself. I used a heat transfer cement that does not seem to have held up.

All in all, my wife, daughter and I are very pleased with our existing house, which uses about 1/6 as much energy as a conventional dwelling the same size. In this next year I hope to be involved with a house that will use about 1/10 as much energy as a conventional house. Stay tuned for the official announcement.☼

High-performance insulation materials

By Phalguni Mukhopadhyaya

The space heating and cooling of buildings consumes a substantial amount of energy. Over the past thirty years, big improvements have been made to reduce building energy use, but further improvements are possible and necessary. Some high-performance thermal insulation materials can be up to *ten times* more efficient than materials currently in use.

Researchers at NRC's Institute for Research in Construction (IRC) have been working with European partners to advance the technology of new generation insulation materials for building applications. Micro- and nano- porous materials, vacuum technology and special gas-filled porous structures are all viable solutions. This article explains the characteristics of vacuum insulation panels (VIPs) and presents some preliminary results of IRC research on their thermal performance.

Dr. Phalguni Mukhopadhyaya is a research officer in NRC's Institute for Research in Construction.

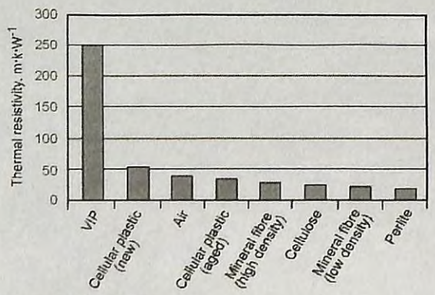

Figure 1. Thermal resistivity of VIPs compared to common insulating materials

Although VIPs are being used in Europe to a limited extent in buildings, their use in North America is still limited to specialized applications like refrigeration and pharmaceuticals. By conducting more research on these promising materials, IRC and others will be able to assist manufacturers and the construction industry to overcome any limitations regarding the use of the technology in building applications.

Benefits

In addition to delivering substantial energy savings and a consequent reduction in CO_2 emissions, VIPs offer several other important advantages. With the development of insulation materials that are ten times more efficient than contemporary products (Figure 1), the thickness of building envelopes can be reduced. In cases where the size of framing members is governed by their ability to contain insulation materials rather than by structural strength, the size of insulation cavities can be reduced, with a saving in materials, a maximization of usable building space and a reduction in waste and recycling needs at the end of the building service life.

The compactness and insulating properties of VIPs are particularly valuable in situations where space is at a premium, such as in building retrofits and in heaters, chimneys, pipe-work and wall assemblies. Their use in Canadian construction could potentially reduce the thickness of building envelopes and substantially reduce energy costs.

What is a Vacuum Insulation Panel?

A vacuum insulation panel is composed of two components: a micro- to nano- porous material called the "core" that is evacuated and sealed using a thin membrane called the "foil" (Fig 2).

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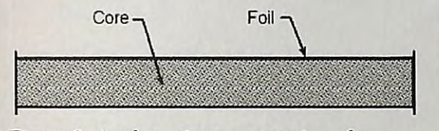

Figure 2. A schematic representation of a vacuum insulation panel

VIPs make use of the fact that the absence or reduction of gaseous pressure inside a porous material increases its thermal insulating potential. This effect becomes even greater in materials that already have high thermal insulating values, and can be increased still further by applying the latest scientific and technological developments in other fields such as nanotechnology.

The initial thermal conductivity of a VIP depends on the pore dimensions of the core and the level of the vacuum retained within the sealed panel. Air molecules and water molecules that permeate the foil and the seams causes a loss of vacuum and thermal resistivity. Thus, the long-term thermal resistance of VIPs depends on the integrity of the foil and its seams. Even one pinhole in the foil or the seam destroys the vacuum and the high performance of the VIP. Ensuring the integrity of the insulation is obviously a challenge in building applications.

IRC Test Program

IRC researchers initiatally tested twelve 30-cm x 30-cm x 30-mm VIPs for thermal resistance. Various batches of panels were subjected to different environmental loads (temperature, relative humidity, and pressure) for more than a year and their thermal resistance was repeatedly determined. In addition, the water vapour permeability of the foil bags and seams was tested.

Samples aged in the laboratory, under standard laboratory conditions, (21 ± 1 °C and about 50% RH), had an initial 6% drop in resistivity; the resistivity then remained constant for the remainder of the year. Other samples exposed to higher temperatures (up to 32°C) and higher relative humidity (up to 90%) showed a similar initial drop in resistivity but were not otherwise affected. Samples exposed to high pressure (5 bar for 30 days and 3 bar for 15 days) resulted in shrinkage of the test specimens and a reduction in resistivity of one half.

Edge Effects. Four specimens were tested edge-to-edge to make one 60-cm x 60-cm test assembly to examine edge effect. The effective resistivity of the assembly was about one quarter the resistivity of an individual VIP specimen. Further work is needed to find ways of reducing thermal bridging at the edges of adjacent panels.

Conclusions from IRC Testing

Based on the information available to date from IRC's investigations, the following conclusions can be made about vacuum insulated panels:

- They exhibit thermal resistivity up to ten times greater than current building insulating materials.
- Damage to the foil bags affects resistivity and thus the methods of providing protection during construction and service need further investigation.
- As found in this study, environmental loads such as high relative humidity and higher than normal indoor temperatures have no measurable effect on performance. However, further investigation is necessary.
- Over-pressure may cause VIPs to shrink but does not totally degrade the high thermal resistivity.
- The thermal bridges at the edges of VIPs reduce effective resistivity, but still leave them with resistivity several times higher than current insulation materials.

IRC is undertaking a new phase of research on VIPs. The work will focus on:

- Confirming and expanding upon the findings of the study reported here;
- Using the latest advances in micro-porous and nano-porous materials to improve VIPs;
- Developing guidelines for the application of VIPs in the field.

The initial project attracted substantial funding for three years from a number of organizations. However, to ensure representation from all interested parties, IRC would also like to include industry partners willing to take an active role in the research and development of VIPs.

Readers interested in learning more or how to become involved may contact Dr. Phalguni Mukhopadhyaya at (613) 993-9600, or e-mail *phalguni.mukhopadhyaya@nrc-cnrc.gc.ca.*

Acknowledgement
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ARCHITECTURAL PRECAST CONCRETE WALLS

Designing with architectural precast concrete

Architectural precast concrete has been used as cladding on buildings since the 1920s. Recently, however, the range of products available has broadened considerably, as manufacturers have begun to incorporate a much wider range of shapes and finishes, new insulating and anchoring methods, and even rainscreen technology.

Today, current panels are manufactured to factory-controlled tolerances, allowing for thinner panels with simplified connections. Composite sandwich panels with punched windows can even provide an entire wall assembly from a single source. However, as with other systems, architectural precast systems remain sensitive to the installation and performance of each component.

To ensure that all the requirements of the building envelope are taken into consideration during both design and construction, **Canada Mortgage and Housing Corporation (CMHC)** has conducted extensive research into how designers can best use architectural precast concrete as an integral part of the building envelope – and make more informed design choices.
To maximize performance, durability and cost-effectiveness, for example, there is a wide range of considerations that the design team must determine when working with architectural precast concrete.

Resources and information

To help answer these questions and many more, CMHC and Public Works Government Services Canada (PWGSC) in collaboration with the Canadian Precast/Prestressed Concrete Institute (CPCI) have published the ***Best Practice Guide: Architectural Precast Concrete Walls***.

The Guide includes two dozen CAD design details and provides designers with a clear, thorough understanding of the product, covering such topics as site practices, building envelope performance, best practice assemblies, types of panels and their manufacture, transport and installation, basic design considerations, quality assurance and maintenance and renewal considerations.

To find out more about architectural precast concrete or order the Best Practice Guide, contact CMHC at **1 800 668-2642** or visit our Web site at **www.cmhc.ca** (order desk).

Canada

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A limited number of back issues are available, at a special price of $5.50 each (plus 7% GST).
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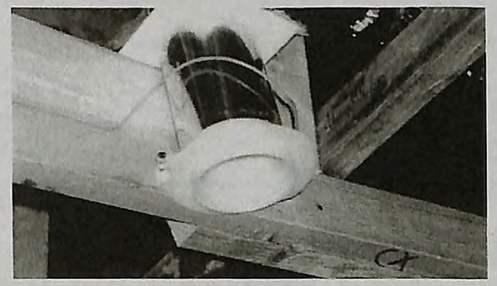

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Research Funding

CMHC's External Research Program offers funding assistance to help Canadian researchers carry out research on housing topics. The intent is to encourage and draw out new ideas, innovative solutions, and better understanding of housing issues. Grants up to $25,000 are available for a limited number of research projects each year. Completed research studies are published by CMHC.

Recipients are selected on the basis of the merit and significance of their proposals by a national committee of housing experts. Committee representatives include experienced researchers and practitioners in government, academic institutions, housing related professions and businesses.

Applications must be sent to CMHC's National Office in Ottawa by midnight October 31, 2004. pplicants must be Canadian citizens or have obtained permanent resident status in Canada. For more information:

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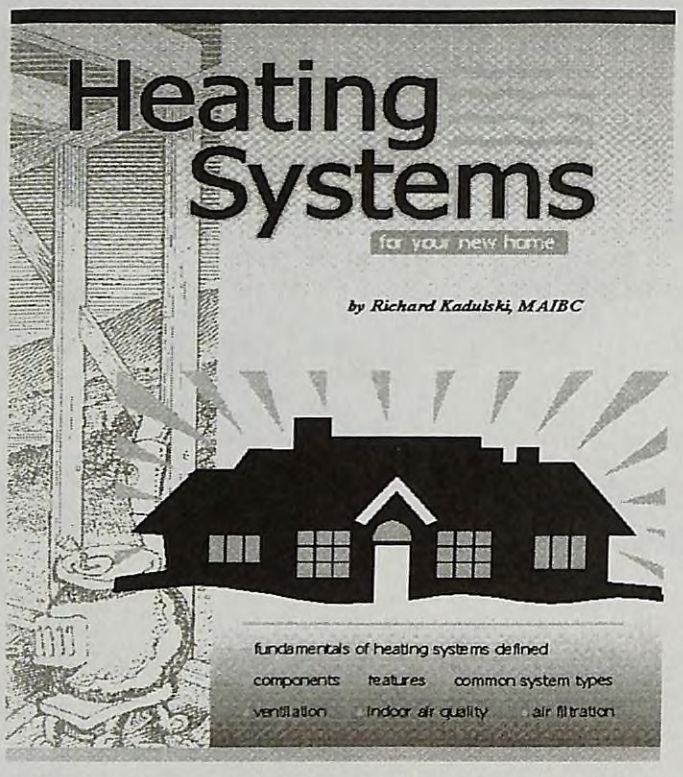
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